

Uncertainties Associated With Atmospheric Dispersion Modeling*

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Abstract

The U.S. Department of Energy sponsored Atmospheric Release Advisory Capability (ARAC), which is operated by the Lawrence Livermore National Laboratory, provides real-time predictions of the downwind environmental and public health impacts of accidental and natural occurring releases of hazardous materials into the atmosphere. These predictions are derived by means of the coupled MATHEW/ADPIC three-dimensional wind field and particle dispersion models. The uncertainties associated with the predictions derived from these models have been extensively evaluated using data from a wide range of tracer experiments. Most recently, we have evaluated the uncertainties by two different approaches. One approach, involved the use of tracer and supporting meteorological data acquired from the DOE sponsored Atmospheric Studies in Complex Terrain (ASCOT) program and the DOE Rocky Flats Winter Model Validation Studies, while the second approach involved participation in a Commission of European (CEC)/ U.S. Nuclear Regulatory (NRC) modeling uncertainty study. This study was focused on an intercomparison of the model predicted concentrations derived by a selected group of European and U.S. modelers who estimated the pollutant dispersion characteristics associated with a standardized set of terrain and meteorological scenarios. This presentation provides a brief overview of these studies and their associated results.

The first approach utilized meteorological and tracer data derived from a series of field experiments conducted during the January and February 1991 timeframe in the vicinity of the DOE Rocky Flats facility situated along the Front Range of the Rocky Mountains near Boulder, Colorado. Analyses of the meteorological data revealed the presence of multiple scales of motion with significant temporal and spatial variations. The cold drainage flows generated over the mountain slopes during the nighttime flowed out of the mountain canyons and subsequently out over the adjacent plains. Regional and synoptic scale flows were found to overlie the drainage flows in a spatially and temporally varying manner. The SF₆ tracer released near the surface at the Rocky Flats facility was almost entirely entrained within the drainage flows during its transport over the two sampling arcs situated at 8 and 16 km from the release site. The MATHEW/ADPIC simulations of the tracer dispersion revealed a generally good agreement with plume observations. However, plume arrival times over the sampling arcs and the detailed spatial variations in plume structure were somewhat less accurately portrayed by the models. Generally, factor of 5 agreement between observed and simulated tracer concentrations were noted for about one-half of the comparisons between model predicted and

observed concentrations at specific sampling locations. Approximately 95% of the comparisons were within a factor of 100. In contrast, model simulations of tracer releases over relatively flat terrain indicate a factor of 5 agreement between model predicted and measured concentrations for about 80% of the comparisons while about 95% of the comparisons were within a factor of 10.

The second approach for defining model uncertainties involved an elicitation process based on the results provided by eight European and U.S. atmospheric dispersion modelers. Each modeler independently derived the concentrations and their uncertainty distributions for a given set of terrain and meteorological scenarios. This required each modeler to estimate the median concentrations at specified downwind locations along with the 5% and 95% quantiles. The methodology used at LLNL was based on (1) the natural variations of boundary layer dispersion characteristics for supposedly similar meteorological and terrain situations, (2) the variability associated with estimating the stability classification, and (3) the uncertainty of measurements due to instrument error or non-representivity. The MATHEW/ADPIC models were used to derive the best estimates of the median concentrations while a fast running sequential puff code was used to define the concentration distributions around the median values. A comparison of the results obtained in this manner with those acquired by the other modelers for a unit release scenario over rural and urban areas indicated that the median concentrations derived by the MATHEW/ADPIC models were generally within the roughly order of magnitude range of all median values. The uncertainty distributions as indicated by the range spread between the 5% and 95% quantiles were typically about a factor of 100 out to a distance of 30 km from the release point.

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